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RESEARCH ON THE OPERATION OF COMMERCIAL VESSELS WITH COMPRESSED AIR

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ABSTRACT

Regarding the reduction of the carbon dioxide emissions in the atmosphere, this paper is going to present a system of propulsion with compressed air used for medium-sized commercial vessels. In the transport domain, Romania holds a key position at the eastern border of the European Union, a transit area, both in the east-west direction (connection with Asia via the Black Sea), and north-south (from the Baltic Sea to the Mediterranean Sea). Three of the priority axes TEN-T cross the territory of Romania. We believe that using compressed air instead of fossil fuels will also determine a fuel economy of approximately 42% leading to the improvement of the companies finances which use these systems.

KEYWORDS: air compressed engine, vessel

1. Introduction

The national transport systems existing in Romania consist in cargo and passengers transport. In these systems, the road, rail (on inland waterway and maritime), air, non-motorized and special (through pipes and air electrical transport) operate. As regards the transport by inland waterway, it is noted that the main ports of Romania are: Constanta, Mangalia, Midia-Navodari, Sulina, Tulcea, Galati, Braila. The use of compressed air for the propulsion for the coastal vessels proves to be effective from the point of view of consumption and autonomy.

The constructive advantage of using compressed air is the fact that can be introduced into a classic type engine by means of a relay and an electro-valve playing the role of a compressed air pressure regulator which is introduced with force into the engine cylinders placing both the crankshaft and the flywheel in rotating movement.

2. Experimental model

For the laboratory experiment an engine with a single piston was used (Figure 1).

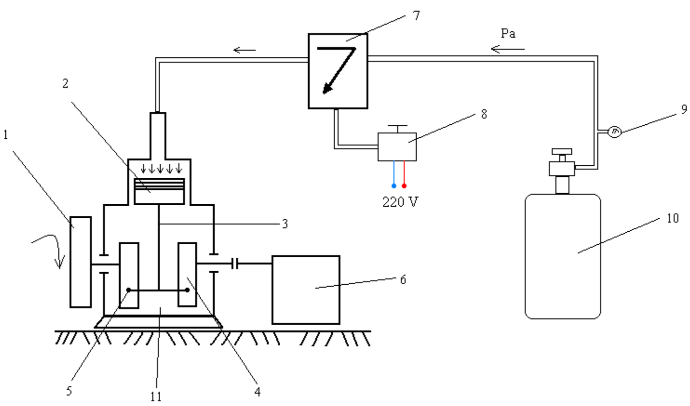

Fig. 1. *Propulsion system constructive schedule: 1 - flywheel; 2 - piston; 3 - con rod; 4 - crankshaft; 5 - button of the eccentric crank; 6 - working machine; 7 - electro-valve; 8 - relay; 9 - pressure gauge; 10 - compressed air tube; 11 - engine with a piston in the two-stroke engines*

The components necessary for making the experiments in optimal conditions are: engine itself - standard construction (with a piston, two-stroke engines); the elector-valve; relay; the cylinders with compressed air; the pressure gauge; the pipes in the high-pressure circuit. The engine itself has electronic ignition, the piston has 48 mm diameter and the stroke of the piston is 62 mm. The engine develops a power of 4.2 HP at 4800 rpm/min, its capacity being of 120 cc.

The prototype system can be used when moving a boat, the source of compressed air in this case being some tubes of oxygen having a pressure 150 bars, a capacity of 8 m^3 air and which at an average consumption of about 4 bar/sec a tube will consume in about two hours (Figure 2).

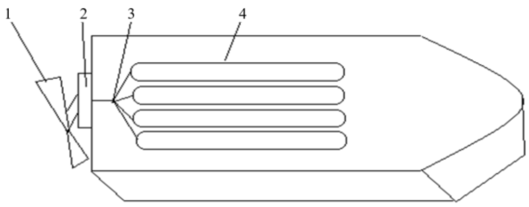

Fig. 2. *Vessel propulsion by compressed air: 1 - propeller, 2 - engine, 3 - joints, 4 - compressed air tubes*

In order to ensure the vessel autonomy for a period of four hours, four tubes of compressed air will be used.

The tubes can also help to a better floatation of the survival craft [1].

3. The engine operation

The compressed air from the gas tubes which forms the supply tank, is released by opening the gas cylinder tap.

The compressed air with pressure between 4 and 8 bar will penetrate into the electro-valve, which has also the role of pressure regulator (similar acceleration from a car), after which, passing through the electro valve, penetrate into the engine cylinder by pushing it.

The flywheel takes over and smoothes out the rotating movement obtained at the shaft of its own [3].

At the shaft of the flywheel, depending on the pressure in the cylinder of the engine, a torque M_{ac} and a speed of rotation will be obtained. The shaft is put in touch with the blades by means of a coupling bolts. The higher the pressure of instilling good will be, the higher the rotation speed and the torque will be, reaching the necessary value for the equipment functioning [2].

3.1. Calculation of engine torque

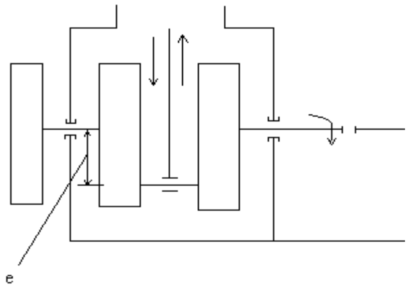

Fig. 3. *Schedule for eccentricity torque calculus*

Torque: $M_{ac} = F_p * e * \cos\alpha$ [Nm]

where: e - eccentricity; e = 0.06;

F_p - force measured using the pressure gauge;

$\alpha = 30°$; $\cos\alpha = 0.86$;

M_{ac} = 88.73 Nm (maximum torque value);

M_{ac} = 14 Nm (minimum torque value).

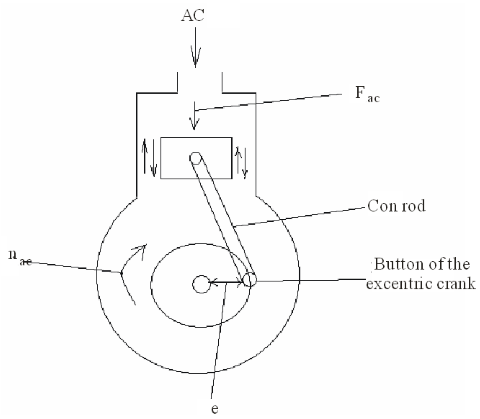

Fig. 4. *Compressed air engine section*

3.2. Rotation speed computation of engine crankshaft

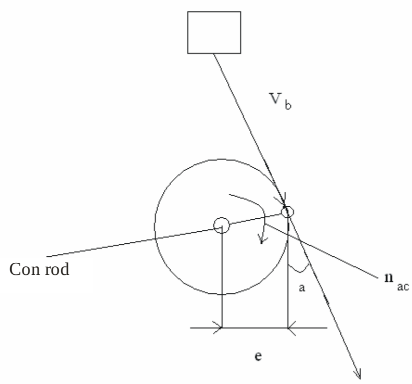

Fig. 5. *Calculus schedule rotation speed and tangentially speeds*

Tangentially speeds:

$$V_b = \omega * e = \frac{\Pi * n_{ac} * e}{30} \text{ [m/s]}$$

Crankshaft rotation speed:

$$n_{ac} = \frac{30\, V_b}{\Pi * e} \text{ [rot/min]}$$

Speed values for:

$$P_{min} \rightarrow v_{min} = 60 \text{ rot / min}$$
$$P_{max} \rightarrow v_{max} = 150 \text{ rot / min}$$

3.3. The power resulting from the motor shaft

$$P = k_d * \frac{M_{ac} * n_{ac}}{9550\, \eta} \text{ [kW]}$$

k_d – overload factor, k_d = 1, 2

$$M_{ac} = F_b * e * \cos \alpha \text{ [Nm]}$$

where: e = 0.06 m
α = 30°; cos α = 0.86
η = 80 %

Power values:

$$P_{vm\,\min} = 1.2\, M_{ac\min} * \frac{P_{\min}}{9550\, \eta} \text{ [kW]};$$

$P_{vm\ min}$ = 1.2 kW

$$P_{vm\max} = 1.2\, M_{ac\max} * \frac{P_{\max}}{9550\, \eta} \text{ [kW]};$$

$P_{vm\ max}$ = 1.8 kW

3.4. Measurements and recordings of the parameters for the prototype

There were measured and recorded the following parameters for the prototype: pressure, torque and speed of rotation, reported in Table 1.

Table 1. *The measured parameters for the prototype*

Parameter	t_1 = 0 s	t_2 = 10 s	t_3 = 20 s	t_4 = 30 s	t_5 = 40 s	t_6 = 50 s	t_7 = 60 s
Pressure after valve [bar]	4.1	4.4	4.6	4.9	5.2	5.8	6.4
Rotation speed [rpm/min]	60	82	96	110	125	136	152
Torque to the shaft to the engine [Nm]	88	93	113	128	145	163	184

It is noted that the same time with the increase of air pressure in the engine, the torque of the crankshaft and the rotating speed of the propeller increase too, meaning the speed of the vessel.

A good quality of the air is essential in order to achieve a maximum output of the pneumatic engine system as regards the capacity, torque, speed and performance. It is recommended that the air with which the supply is carried out to be filtered and regulated by the use of a filter, a pressure regulator and an air regulator.

4. Conclusions

From a technical point of view, the pneumatic motors are reliable and due to their mode of operation, they can be used in several types of applications. The engine is part of the pneumatic circuit, together with a pump, valve, filters, connectors and others. Each item has its role, or the compressed air from the reservoir is supplied under pressure to the engine, which is connected directly to the drive system. Pneumatic engines are precise forces in various applications because of their technical advantages. These systems are easier to maintain and have a greater longevity than the electric motors or the complex mechanical systems [4].

While the electric motors sizes are proportional to the power that develops, the pneumatic engines are much smaller, relative to the same task. The electric motors have constant need of electric power and must be placed directly on the axis of the movement, a difficult thing in different situations. For the same application, a pneumatic engine system with small dimensions can be easily connected to a pump through a system of flexible hoses that can be placed easily even in small spaces.

Pneumatic motors work even after the interruption of the pressure air source. The operating chamber, after being filled with compressed air, closes securely and loses the connection with the pressure source.

The compressed air expands, assigns its energy to the mobile component of the engine at the same time with its decrease in temperature. Such an engine is operated in such a way with the cycle of the expansion bottle. There are pneumatic engines which operate after a mixed cycle i.e. the first part of the cycle works with full pressure, so the engine is in connection with the source of the compressed air and the second part, after a cycle of expansion.

The efficiency of the pneumatic engines depends on the pressure and air flow rate with which the moving system is supplied. By adjusting the pressure and the flow of air, the torque and the pneumatic engine speedy can be adjusted.

References

[**1]. Demian Tr., Banu G.**, *Micromotoare pneumatice liniare si rotative*, Editura Tehnica, Bucuresti, 1984.

[2]. Stanescu A. M., Banu V., Atodiroaei M., Gaburici V., *Sisteme de automatizare a echipamentelor pneumatice*, Editura Tehnica, Bucuresti, 1987.

[3]. Radcenco V., Alexandrescu N., lonescu M., Ionescu M., *Calculul si proiectarea elementelor si schemelor pneumatice de automatizare*, Editura Tehnica, Bucuresti, 1985.

[4]. Lazea Gh., *Echipamente de automatizare pneumatice si hidraulice –indumator de laborator*, Editura Lito IPCN, Cluj-Napoca, 1982.